Influence of habitat heterogeneity on the pearl millet head miner biocontrol in Senegal.

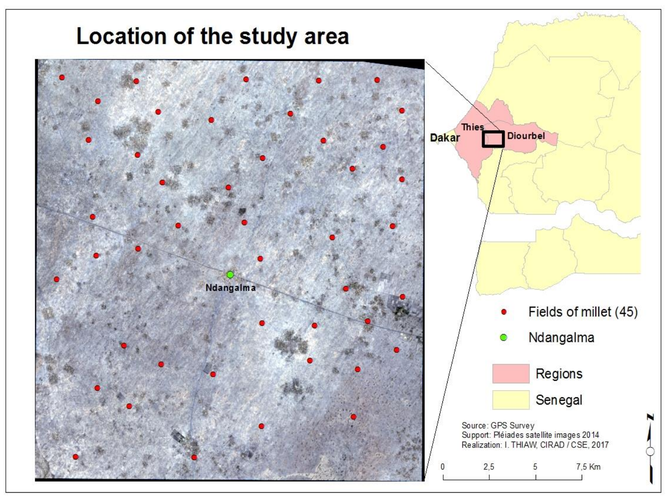
Ibrahima THIAW[1, 3, 5], Valérie SOTI[1, 3], Thierry BREVAULT[1, 2], Ahmadou SOW[2], Cheikh THIAW[4] Mouhamadou DIAKHATE[5]

1. **CIRAD**, UPR Aïda, Equipe Carabe, Montpellier, France.
2. **Biopass,** centre commun Isra-IRD de Bel-Air, BP 1386, Dakar CP 18524, Senegal
3. **CSE**, Centre de Suivi Ecologique, Fann résidence, Dakar, Sénégal.
4. **ISRA**, CNRA, Bambey, Senegal.
5. **UGB**, Laboratoire LEIDI, Saint Louis, Senegal.

Contact : thiawmy@gmail.com

Scientific context

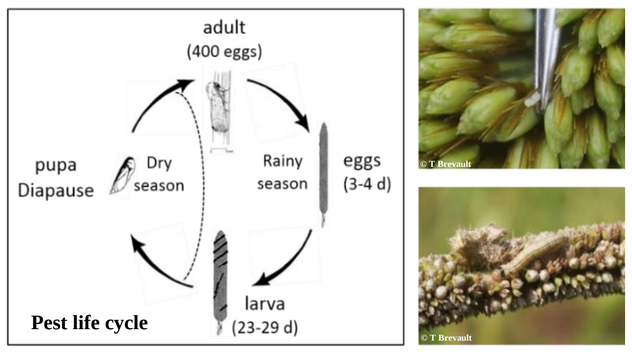
Bambey area



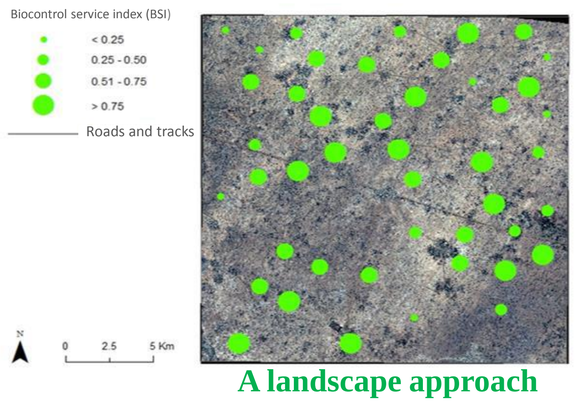
This area is characterized by an agroforestry system associating *Faidherbia albida* with cereals (millet) and legumes (cowpeas and groundnut).

Insect pest: *Heliocheilus albipuntella*

- The millet head miner (MHM), *Heliocheilus albipunctella* is the most damaging millet pest in West Africa);
- Observed fot the first time in Senegal and in Niger after the Sahelian drought of 1986-1972 (Nwanze and Sivakumar, 1990);
- One year life cycle and larval stage has three instars;
- Adults emerge one month after the first useful rains and after mating, the females will lay eggs;
- After hatching, lavar start feeding millet head;
- Then the larvae pupate in the soil throughout the dry season.



A high spatial heterogeneity of MHM natural regulation



A landscape approach

- No insecticide treatment
- Same cultural practices
- Same millet variety

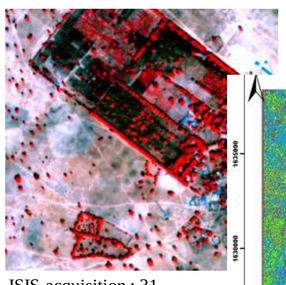
The main hypothetize based on landscape heterogeneity influence

Landsacape composition

Goal -> Study the effect of landscape elements on the natural regulation of the *Heliocheilus albipunctella*

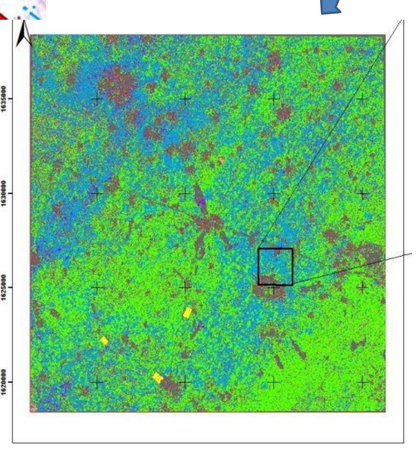
Methodology

Image satellite Geoeyes



ISIS acquisition : 31 december 2013
Spectral bands : Blue, green, red, PIR
Spatial resolution : XS => 1,65 m ; Pan => 0,41 m

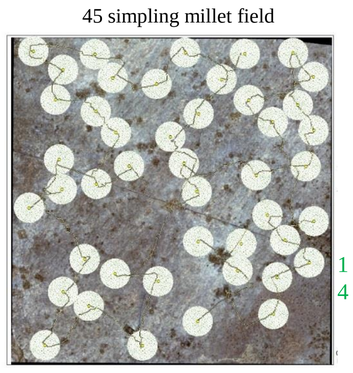
Classification OBIA



Land cover map

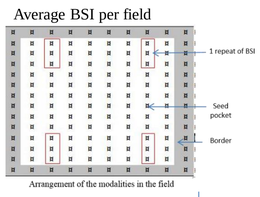
Entomological data

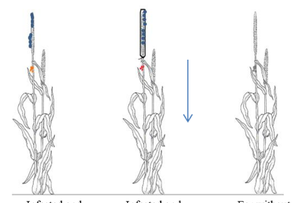
45 simpling millet field



1 ear per modality
4 replicates per plot

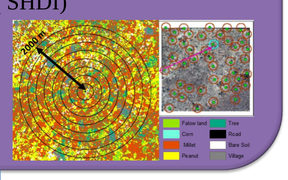
Average BSI per field





5 explanatory variables

1. Millet Patch Abundance Index (MPAI)
2. Tree Patch Proximity Index (TPPI)
3. MilletPatch Proximity Index (MPPI)
4. Shannon diversity Index (SHDI)
5. Tree Density Index (TDI)



Variable to explain

Biocontrol Service Index (BSI)

$$BSI = \frac{L_M - (LT_1 - LT_0)}{L_M}$$

Chaplin-Kramer and Kremen, (2012); Woltz and al. (2012)

L= nomber of larvae after 18 days.

BSI varies between 0 and 1
- If BSI = 0% absence of regulation
- If BSI = 100% perfect regulation

Statistical analysis (GLM Backward)

AICc

Key landscape variables

Results

Statistical analysis

- **The 9 best models according to their buffer size in the Bambey** $AICc = AIC + \frac{2k\,(k+1)}{n-k-1}$

Taille de buffer(m)	Modèle	Paramètre (nb)	AICc	Diff AICc
1750	TDI+MPAI+SHDI	3	-14,96	0,00
2000	TDI+MPAI+SHDI	3	-14,06	0,90
2250	TDI	1	-13,87	1,08
500	MPAI+SHDI	2	-13,84	1,12
1500	TDI+MPAI+MPPI+SHDI	4	-13,69	1,26
1250	TDI+MPPI+SHDI	3	-12,42	2,54
1000	MPPI+SHDI	2	-11,46	3,50
250	MPPI+SHDI	2	-10,90	4,06
750	TDI+MPPI+SHDI	3	-10,87	4,09

The model at 1750 m is the best statistical model, explaining the BSI value.

- **Among the 5 landscape variables, 3 are the most significant**

Estimate	Estimate	Std.Error	t-value	p-value
(Intercept)	-1.650e-01	2.937e-01	-0.562	0.5764
TDI-1750	8.379e-05	3.252e-05	2.576	0.0126 *
MPAI-1750	-2.793e-04	1.243e-04	-2.248	0.0284 *
SHDI_1750	5.114e-01	2.235e-01	2.289	0.0258 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.2034 on 59 degrees of freedom
Multiple R-squared: 0.1739,
Adjusted R-squared: 0.1319
F-statistic: 4.14 on 3 and 59 DF, p-value: 0.009905

- **TDI, MPAI and SHDI are correlate with the BSI value**
- **BSI values increase with the SHDI and the tree density index (TDI)**
- **BSI values decrease when the Mil Patch Proximity Index (MPAI) decrease**

Conclusion and perspectives

The result of the study confirms our hypothesis based on the effect of natural vegetation and more specifically of trees and landscape diversity as potential landscape elements promoting *Heliocheilus albipunctella* natural regulation. Conversely, natural regulation of *Heliocheilus albipunctella* populations decreases in aeras with a hight density millet.

The study show also the contribution of satellite images for land cover mapping at a finer scale and more specifically for landscape variable calculation on larger area. In spite of these positive points, the results of the statistical analysis could be improve.

Therefore, in perspectives:

- First, we propose to identify tree species that have a direct impact on the natural regulation of the millet pest.
- Secondly, we suggest to test other models such as linear mixed effect in order to capture the year effect and also to take into account all possible variables combinaisons.
- Finely, if these results are confirmed, a risk map using a model inversion method could be useful to identify favorable areas for MHM biocontrol.

Study realized as part of the TRECS project, funded by APR CNES.

Landscape 2018 Frontiers of agricultural landscape research **12–16 March 2018** Berlin, Germany